

Chapter 7 Discharge System

7-1. General

The discharge system of a pumping station is used to convey the pumped water from the pumps to the receiving body of water. Additional discharge system information is contained in EM 1110-2-3102. Two types of systems are used, over the levee either with or without siphon recovery and through the line of protection. Alternative studies of different type discharges may be required in order to select the one that is best when considering the layout of the station, site requirements, and the selection of the pumping equipment.

7-2. Discharge Types

a. Over the levee. Discharge lines over the protection consist of individual lines for each pumping unit or a manifold discharge with one discharge line running from the station over the protection. The lines can terminate in a common discharge structure or each individual discharge line can be supported by piling with the surface below riprapped to prevent erosion. If the discharge system is to operate as a siphon, the design should be such that it is self priming and the lowest discharge level should not be lower than 8.5 meters (28 feet) from the top of discharge pipe (this limit, as illustrated in Appendix B, does not include piping losses, velocity head, etc.). The 8.5 meters (28 feet) may be obtained by terminating the discharge lines in a concrete box containing a seal weir at the proper elevation. An upturned elbow may also be used to obtain the seal elevation on individual lines. The invert of the discharge line at its highest point should be at or above the level of protection expected to be provided by the protection works. Manifolding of pump discharge lines into a single line is generally cost effective only for small pumps and when siphon recovery will not be used. When considering a manifold system, a cost comparison should be made between the cost of individual discharge lines and the extra shutoff and check valves needed in a manifold system. Pumps that discharge into an open discharge chamber are not considered to be manifold-type discharge.

b. Through the protection. Discharges through the protection usually consist of individual pump discharge lines terminating in a discharge chamber or wall of the protection. Flow from the discharge chamber would then be carried by conduit to the receiving body of water.

7-3. Selection Criteria

The type of discharge is sometimes set by the location of the station. For example, siphons may be used when the station is located behind the levee or as an integral part of the levee. In those cases where different types of discharge arrangements could be used, a study of alternatives should be made. Selection is based on a life-cycle cost analysis. Some of the variables would be operating, equipment, and structure costs. Operating costs would include the costs of energy, manpower, and operating supplies and maintenance costs. Energy and manpower needs should be determined using available hydraulic/hydrology data to determine amount of operation time and discharge levels. Forecasts of future energy costs can usually be obtained from the utility that furnishes the energy. Equipment costs could vary due to the difference in discharge head requirements of the various discharge systems. In most cases, only the driver size would change. Although over the levee discharges with a siphon recovery make pump selection more difficult due to the fact that the pump is required to operate over a greater head range, it does reduce the operating costs of the station. The static head for a siphon recovery discharge is based on the pool-to-pool head, whereas the static head for a non-siphon discharge is based on the maximum elevation of the discharge line. A study should be made of the first costs and operating power costs to determine if the siphon assist is justifiable.

7-4. Design

a. General. The size of the pipe is usually determined by a cost analysis of the energy used due to friction loss versus pipe cost. Through the protection, discharge lines are usually short lines and have the same diameter as the pump discharge elbow. Where any piping connects to a pump, it should be supported so that the pump does not support any of the weight of the pipe or its contents.

b. Through the protection. In general, two means shall be provided to prevent backflow when the discharge is through the protection. Discharge lines through the protection should terminate with a flap gate to prevent back flow. In addition to the flap gate, provisions should be made for emergency shutoff valves, emergency gates, or individual stop log slots to place bulkheads in case of flap gate failure. All discharge lines with flap gates should be fitted with a vent pipe located just upstream of the flap gate to prevent excessive vacuum bounce of the flap gate. The vent should extend 600 millimeters

(2 feet) above the highest discharge water level. Flap gates shall be of the type suitable for pump discharges. This type of gate is of heavier construction, and the arms that support the flap are double hinged so that the flap will fully close. Flap gates with a built-in hydraulic cushion effect are not required where the head on the gate is below 7.6 meters (25 feet). All non-cushion type flap gates used on pump discharges should have a rubber seat which aids in sealing and eliminating some of the closing shock. A station having this type of discharge arrangement is shown on Plate 5.

c. Over the levee. Pipes over the levee require an air release and a siphon breaker at the crest. If the pipe system does not operate as a siphon, a permanent vent opening can be used. Discharge pipes 1,500 millimeters (60 inches) and less can usually be operated as a self-priming siphon if the flow velocity at the crest is 2.2 meters per second (7 feet per second) or greater when priming is initiated. Model tests should be considered for discharge pipes of greater diameter and those pipes having an arrangement different from the standard type discharge shown on Plate 4. For pipes operating as a siphon, the use of a remotely operated valve to break the siphon should be used. This valve is air-operated except for small sizes in which electric operation is possible. The valve is operated from a signal initiated by the starting of the pumping unit. A timer is placed in the circuitry to provide a time delay of valve closing after start-up to vent the discharge pipe system. There are flow-operated siphon breakers available, but care should be taken that they are designed for heavy duty operation and are adjusted correctly after installation to prevent air leakage into the pipe. The siphon valve is sized according to the formula provided at the end of this paragraph. When the calculated result indicates a non-standard size valve or piping, the next larger standard sized valve and piping should be used. A manual valve of the same size shall be used in addition to the siphon valve for emergency breaking of the siphon. All of the siphon breaker piping and valves should be located near the descending leg in an enclosure. Problems in priming the siphon can occur when the changes in discharge line gradient occur on the discharge side of the protection. The section of pipe after the down leg should be as flat as possible to prevent these problems. Manufacturers of air and vacuum valves should be consulted for proper valve sizing. Vent size can be calculated using the following formula.

$$D_v = 0.25 D_p \times (2/h)^{0.25}$$

where

D_v = diameter of vent, ft
 D_p = diameter of discharge pipe, ft
 h = minimum submergence over outlet, ft

7-5. Pipe Construction and Material

a. Construction. Discharge piping to pump connections is generally made by means of a flexible coupling with harness bolts across the connection. Rigid or flanged connections could be used for pullout design pumps and for those pumps that may be cast into the structure. All buried piping needs to be connected with flexible couplings with harness bolts whenever the pipe runs into or out of a concrete structure, at bends, and at other points where differential settlement or normal expansion or contraction of the pipe is anticipated. Where piping leaves a structure and goes underground, the first flexible coupling should be placed within 1.5 meters (5 feet) of the wall with an additional flexible coupling placed 1.5 meters (5 feet) farther downstream. An embedded wall flange should be provided for all piping passing through concrete walls. Pipe selected should be of the minimum wall thickness that will satisfy the requirements of the installation and, if possible, should be of a standard stock wall thickness. Where corrosion may be a problem, an increase in thickness of 25 percent may be considered for steel pipe. In addition to the tensile circumferential stresses resulting from the normal internal water pressure, stresses due to the following may be a consideration in the design of some pump discharge lines.

- (1) Excess stress due to water hammer.
- (2) Longitudinal stresses due to beam action of the pipe, when the pipe is exposed and supported by piers or suspended supports.
- (3) Stresses caused by external loading.
- (4) Stresses caused by collapsing pressures due to formation of vacuum in the pipe.
- (5) Stresses due to temperature changes.
- (6) Stresses due to differential settlement.

The discharge pipe and its support system including anchors, thrust blocks, and tie rods should be designed in sufficient detail so that the above considerations can be checked. American Water Works Association (AWWA) Manual M-11 should be referenced for recommended design and installation practices for steel pipe. Preparation of detailed pipe shop fabrication drawings should be made the responsibility of the Contractor subject to the approval of the Contracting Officer.

b. Material. Discharge piping should be constructed of steel or ductile iron. Ductile iron pipe would generally be

used for piping of 300 millimeter (12-inch) diameter and under. Exposed steel piping inside of stations may be flanged or flexible coupling connected, whereas ductile iron pipe should be fitted with mechanical joints or flanged. Steel and ductile iron pipe should conform to the applicable AWWA standard specifications. All discharge line pipe should be protected on the inside with a smooth coating. The designer should consult with the paint laboratory at the Construction Engineering Research Laboratory, Champaign, IL. Buried pipe should also be provided with an outer protective coal-tar coating and a felt wrapping. Shop coatings should be used to the maximum extent possible due to the better quality control. Flanges should conform to AWWA specifications for the pressure rating required. The applicable AWWA standards are listed in Appendix A. Valves should be selected that will be easily maintained. Unless larger than 1,200 millimeters (48 inches), gate and butterfly type valves are preferred. Gate valves with cast iron bodies should be bronze fitted. Butterfly valves should be rubber seated. The type of valve operator, either electric or manual, is the designer's choice based on site-specific requirements, e.g., accessibility, frequency of use, and anticipated loads.